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HIGHWAY INFORMATION SYSTEM

RELEASE 4.Ø

SYSTEM OVERVIEW

STATE DOCUMENTS

Department of Civil Engineering & Engineering Mechanics Montana State University Bozeman

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SYSTEM OVERVIEW

STATE DOCUMENTS

Prepared for the:

STATE OF MONTANA
DEPARTMENT OF HIGHWAYS
PLANNING AND RESEARCH BUREAU

In cooperation with the:

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

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FOREWORD

This report is a portion of the documentation of Release 4.Ø of the Highway Information System undertaken by the Department of Civil Engineering and Engineering Mechanics, Montana State University. The retrieval system has been evolving over the last several years under the sponsorship of the Planning and Research Bureau of the Montana Department of Highways with some assistance from the Highway Traffic Safety Division, Montana Department of Community Affairs.

Release 4.Ø of the Highway Information System is documented in the following volumes:

Highway Information System Release 4.Ø: System Overview

Provides an introduction to the Highway Information System.

Highway Information System Release 4.Ø: Index

Provides an index to all manuals except the System Overview and Program Listings.

Highway Information System Release 4.Ø: User's Manual

Describes how to use the Highway Information System for retrieving information and for printing reports and summaries.

Highway Information System Release 4.Ø: Data Coding Manual

Describes the data card formats for entering data into the Highway Information System files.

Highway Information System Release 4.Ø: System Maintenance Manual

Provides information for performing scheduled system backups and file reorganizations and for allocating system files.

Highway Information System Release 4.Ø: Record Formats & Subroutines

Describes the internal record formats of the various files and provides calling sequences to subroutines. This manual is intended for persons writing new programs to add to the Highway Information System.

Highway Information System Release 4.Ø: Programming Details

Describes the existing programs and provides a guide to the program listings. This manual is intended for persons maintaining existing software in the Highway Information System.

Highway Information System Release 4.Ø: Program Listings

Contains computer-generated listings of all source programs of the Highway Information System.

Although the project was conceived, initiated, and primarily funded through the Planning and Research Bureau of the Montana Department of Highways, the development cost of selected portions of the system was borne by the Highway Traffic Safety Division of the Montana Department of Community Affairs.

In developing the system, the CE & EM Department has had the privilege of using an IBM OS/VS1 370/145 computer located at the Data Processing Bureau of the Montana Department of Highways in Helena. PL/I has been used for most of the programs because of its versatility and ease of use. BAL (assembler) has been used for most input-output modules and for other modules that require its increased capabilities and efficiency over PL/I.

The project could never have progressed to its current state without the continued and patient encouragement and assistance from the Planning and Research Bureau and the Data Processing Bureau of the Montana Department of Highways, and from the Highway Traffic Safety Division of the Department of Community Affairs.

The project conclusion was also hastened by the significant effort of other project personnel: Scott H. Danforth, R. Helene Knowlton, and Doug M. Geiger.

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CHAPTER 1

INTRODUCTION

Montana's Highway Information System (HIS) is a computerized, integrated file system consisting of a large number of separate but related data files and a sophisticated set of specially written computer programs (software) for accessing those files. The design characteristics of this system are discussed in Chapter 2.

Some of the major types of data contained in the system include roadway characteristics, traffic volumes, traffic accident data, railroad crossing information, bridge information, and skid test results. Each of these types of data plus some additional ones are elaborated on in Chapter 3.

Depending upon the location of the feature or event in question, one of three different location methods is used. The primary method is a reference posting system which Montana calls a "true mileage" system. All three of these methods are discussed in Chapter 4.

There are always improvements that can be made in any system, and that is the case for this system as well. These potential improvements primarily consist of addition of new data, refinements of existing analysis techniques, and provision of brand new analysis techniques. Some such improvements which could be made in HIS are enumerated in Chapter 5.

The final chapter in this Overview volume, Chapter 6, discusses both the availability of the HIS software and the availability of more detailed HIS documentation.

Historical Background

HIS was conceived in 1969 when the Department of Highways gave Montana State University (the University) a HP&R contract to begin software development. That first contract was followed by additional Department of Highways contracts and by contracts with the Highway Traffic Safety Division of the Department of Community Affairs, the office of the Governor's Representative for Highway Safety. HIS was not developed overnight, but rather individual subsystems were developed as either opportunity or necessity presented itself.

The complete set of documentation of which this Overview Manual is a part constitutes the final product of the most recent Department of Highways contract with the University. The primary task performed during this last contract has

been the insertion of fairly generalized data selection capabilities into much of the HIS software. To differentiate this latest set of HIS software from its predecessors, this latest set is referred to as Release 4.0 of HIS.

Although originally justified solely on the basis of time and cost savings in generating on-going reports, even then it was realized that the most notable long term benefits would occur in the provision of general inquiry capabilities (data selection and data analysis). The University and the State have participated jointly in the conceptual development of the system. Over 90% of the software composing HIS has been written by the University under contract to the State. The remainder has been written by the Department of Highways Data Processing Bureau.

Computer Details

The system is housed on the Department of Highways IBM OS/VS1 370/145 computer in Helena. It is written in a combination of PL/I and Basic Assembly Language (BAL). Most of the software is in PL/I, but BAL has been used for most input-output modules and for other modules requiring its flexibility and efficiency.

The software consists of a supervisory module (which runs under the control of IBM's OS), many application modules, and a large number of common routines shared by two or more application modules. As a consequence of the system design philosophy discussed in the next chapter, all data files, even those which are usually read sequentially, are of necessity stored on direct access devices. ISAM is used extensively.

CHAPTER 2

SYSTEM DESIGN CHARACTERISTICS

Perhaps the strength of HIS is that it has good, high design standards. Although there are a few unfortunate exceptions, these standards have usually been met. Some of these system design characteristics or standards are discussed below.

User Orientation

This is undoubtedly the greatest single strength of HIS. From the very beginning, a conscientious effort has been made to develop a system which technicians and others possessing negligible computer knowledge can easily use. This effort has been pointed in two different directions.

All input data are subjected to extensive data validity checking or editing. When data fail those edits, descriptive and documented error messages are printed.

Even more significant, all system actions are initiated by an English language type command whose structure is easy to learn and use. Further, cataloged procedures are used to greatly minimize the number and complexity of the system control cards (Job Control Language or JCL) which the user must furnish.

As an example of the user orientation, assume that you want to summarize by day of the week and by time of day those traffic accidents which occurred during the first two months of 1976 in Gallatin County. Since HIS has an existing program for generating such a summary, the five cards shown below will accomplish the desired task (the COUNTY, START-DATE, and END-DATE parameters could occur in any sequence):

```
//     JOB    necessary accounting information
//     EXEC HISACC
//SYSIN  DD *
:SUM-BY-DAY-&-TIME,COUNTY=GALLATIN,START-DATE=01/01/76,END-DATE=02/29/76
/*
```

Root Data

Original, raw, unmanipulated data are used almost exclusively. This minimizes the chance of errors in the input data and gives the maximum possible

flexibility in that the computer can assimilate the data in a large variety of ways. It also reduces data preparation costs.

The biggest violation of this standard occurs in the traffic file. Manually computed AADT's rather than unfactored field counts are used to create that file. This exception was made early in the development of HIS due to the demands for expediency. However, the State has never elected to go back and alter that approach.

Data Integrity

Data integrity refers to the highly desirable situation wherein only accurate, complete, up to date, internally consistent data are included in the data base. To paraphrase an old adage, if there is garbage in the data base, the output of the system will be garbage.

HIS attempts to achieve data integrity in a variety of ways: extensive editing is done on data entry, no data elements are duplicated between or within data files, and the data already in the system are subjected to continual scrutiny. Another important ingredient for data integrity is to have one individual rather than a group of individuals responsible for maintaining specified data elements.

Data Security

Data security refers to the protection of the data base from natural or man-caused destruction, alteration, or unauthorized use. In the case of destruction or alteration, it includes the recovery from such a situation.

Some data security provisions have been incorporated into HIS. For example, individual "programs" such as those used to update or modify a data file can be password protected to prevent unauthorized use.

Another aspect of data security is periodically making backup copies of the data files and storing those backup copies in a safe location. HIS includes software for making such backup copies and for restoring the data files from those tapes.

Direct Access

All HIS data files are maintained on direct access devices (discs as contrasted to computer tapes). HIS gets much of its power through the use of direct access input-output, and the whole system is tied to that methodology.

This methodology speeds data access, permits "simultaneous" access of a single data file by several users, simplifies data management (updating records), reduces operator intervention, and facilitates future conversion to an on-line system.

On-Line Potential

An on-line system is one in which file updates, analysis runs, etc., are performed in a dialogue fashion almost at the very instant the commands are submitted by a user sitting at a computer terminal.

HIS is not an on-line system. However, it has been designed such that it could be converted from a batch system to an on-line system either in total or in part with as minimal effort as possible.

Even the current system can approach the characteristics of an on-line system through the process of submitting batch jobs from a computer terminal. The University has followed this procedure in its software development efforts with great success thus easily overcoming the 80 miles separating Bozeman and Helena.

CHAPTER 3

SUBSYSTEMS

HIS consists of an ever increasing number of subsystems. Each subsystem is comprised of one or sometimes more data files and a corresponding set of software. In spite of the fact that some applications will use software and data exclusively from one subsystem, these subsystems are not independent; they are interrelated.

Typically, each subsystem includes software for report generation, general inquiry, and data management. Report generation capabilities consist of the generation of programmed, predefined listings and summaries.

The general inquiry software usually includes data selection capabilities and data analysis capabilities. The data selection provisions implemented in the system consist of the capability of selecting or limiting the input data used in generating one of the predefined reports, summaries or analyses. Data analysis refers to a more sophisticated use of data normally incorporating some decision making capability. An example would be the accident clusters program which identifies groups or clusters of accidents along a route.

Data management software exists to create files, update and edit those files, make backup copies of those files, and restore files from backup copies.

The primary subsystems are briefly discussed in the remainder of this chapter. Not discussed are such subsystems as the rural sign inventory, urban sign inventory, and emergency medical technician subsystems.

Roadlog

The roadlog file contains such information as system (Interstate, FAP, FAS, FAU, etc.), route number, milepoint, section length, verbal description, administrative information, jurisdictional information, year built, year improved, number of lanes, width, and surface and base materials.

In conjunction with the true mileage file, this file is the basic building block of the entire system.

True Mileage

As discussed in the next chapter, the basic location method used outside of urban areas is a reference posting system. The true mileage file contains the true or actual distance from the beginning of a route to each reference post along the route. This permits the computer to convert any milepoint (a location identification coded in true mileage format) to the actual distance from the beginning of the route.

Traffic

The traffic file contains such information as design hour volume and, for each of the past three years, AADT, percent out-of-state vehicles, percent pickups, and percent commercial vehicles.

Sufficiency

Montana uses a sufficiency rating methodology for allocating FAP construction funds to the various financial districts. The necessary computations are performed by the HIS sufficiency software using data in the sufficiency file. These data include design and average speeds, terrain classification, sight restriction information, geometric constraints, and road condition ratings.

Accident

The Montana Highway Patrol uses HIS accident subsystem data management software for creating and maintaining the HIS traffic accident data files. These accident files are used directly by three different state agencies and indirectly by other state agencies. In addition, several local governmental agencies use these files by going through one of the three state agencies mentioned previously.

Software capabilities include the generation of many different summaries including the National Safety Council Form 16 summary, the generation of an accident-by-sections report to identify those highway sections having accident rates in excess of a statistically computed critical limit, the identification of those urban intersections having a large number of accidents, and the identification of groups or clusters of rural accidents. The Department of Highways uses the clusters program for identifying potential locations for safety

improvements, and the Highway Patrol uses it for determining where to concentrate their selective law enforcement efforts.

Railroad Crossing

The railroad crossing file contains railroad/track/train information, sight distance information, and protection information. It permits the identification of high hazard crossings.

Bridge

This file includes design data, clearance information, and condition information. Several different reports are generated by this subsystem, some of which are required by the federal government.

Skid Test

Montana, as well as other states, has a skid test vehicle which they use both for the routine collection of pavement skid test inventory data and for special studies. Appropriate data from all such tests are incorporated into the skid test file.

CHAPTER 4

LOCATION METHODS

There are currently three different location methods implemented within HIS: rural milepoint, rural non-milepoint, and coordinates. A given location or event is coded to one of these three methods. There is no freedom of choice in the decision; it is dictated by the particular combination of such factors as (1) whether the route in question is inside or outside the city limits, and (2) whether the route has been assigned milepoints. In addition to those three methods, it is sometimes permissible to fail to code precise location information on certain events such as some accidents.

Rural Milepointed

This method is currently used for all rural, on Federal-Aid system locations. Conceptually, it could be used (and is used in some cases) for any route, rural or urban, that is assigned milepoints, regardless of whether or not reference posts have actually been placed in the field.

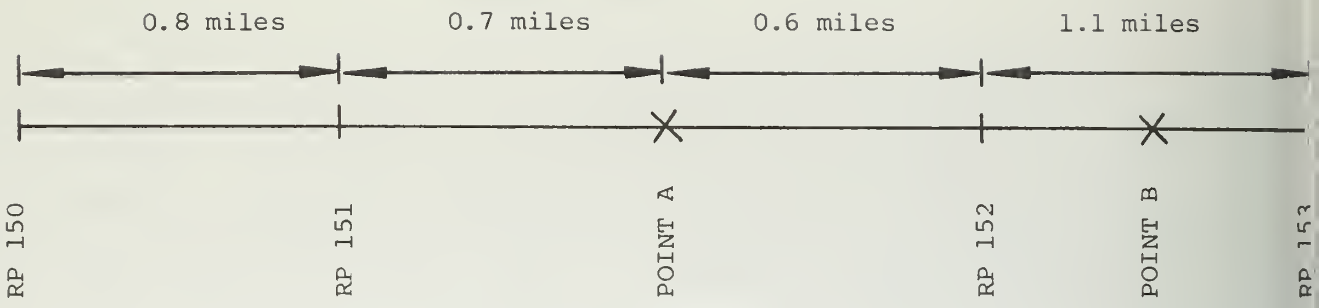
Frequently referred to in Montana as the true mileage concept, this system is actually a reference post system which has the external appearance of a mile post system. Routes start at reference post (RP) 0 and reference posts are numbered consecutively to the end of the route. However, there is no requirement that consecutive reference posts be located exactly a mile apart. Some are a few thousandths of a mile apart; others are over four miles apart. Most, however, are close to if not exactly a mile apart.

An example of a true mileage format milepoint would be:

132+0.920

This is interpreted as a location 0.920 miles away from RP 132. Since the sign is plus, we are 0.920 miles "beyond" RP 132 (closer to the end of the route).

Look at the below diagram. Among other possibilities, the milepoint of Point A could be <u>coded</u> as 150+1.500, 151+0.700, 152-0.600, or 153-1.700. Regardless of how the milepoint was coded, the software would consult the true mileage file and actually <u>use</u> a milepoint of 151+0.700. If the record is being inserted in a data file, the milepoint of that record in the data file would be 151+0.700.



Given any milepoint, HIS can compute the true mileage of that point from the beginning of the route by consulting the true mileage file. Thus, in the above diagram, HIS can easily compute the distance from Point A to Point B by first computing the true mileage of those two points and then subtracting one from the other.

These computations are very simple and are quickly performed by the computer. Since the system is basically a reference post system, it provides a great deal of flexibility while still having the ability to easily relate one point to another. For example, there is no need to place a reference post in the center of an intersection, on a bridge, or in a tunnel.

Even more important, route adjustments can be made with no impact on previously coded milepoints on unaltered portions of the route and minimal if any impact on previously coded milepoints in the immediate vicinity of the change.

Rural Non-Milepointed

A separate location method is used for accidents occurring in rural areas on non-milepointed routes (which usually means on non Federal-Aid routes). It consists of coding the section, township, range, and one digit x and y coordinates within the section.

The system has negligible capabilities for data coded with this method.

Coordinates

Each of Montana's 126 cities has a coordinate system assigned to it. Skid tests, accidents, etc., occurring within one of these cities are either assigned appropriate x and y coordintes or else entered into the system without specific location information. It is expected that all locations on Federal-Aid routes

will be assigned coordinates. If furnished with a grid table consisting of intersection coordinates, the accident subsystem can identify high accident intersections by examining the assigned coordinates of individual accidents.

A variation of the coordinate method is used in the urban sign inventory subsystem. Other variations are being considered in order to achieve maximum usability of the basic data. Eventually, each street may be milepointed.

CHAPTER 5

POSSIBLE IMPROVEMENTS

Regardless of how good a system is, it can always be improved. New capabilities could be added and existing capabilities improved. Some such improvements which could be made to HIS are discussed in this chapter.

The system currently lacks both horizontal and vertical alignment data. If a geometrics file were created, it would be possible to incorporate geometric data into accident analysis procedures and even to produce computer generated plots.

The traffic subsystem should be revised to get back to or at least approach the design philosophy of inputting only raw data. The current use of manually computed AADT's restricts the flexibility of the file and results in too long a time delay before new data are available in the system.

Currently, the roadlog and various other files contain the "as of today" data. If one wishes the data corresponding to the physical situation as of two years ago, it is necessary to restore the backup copies of the outdated files that hopefully correspond to that point in time. It would not be easy, but the files and software could be restructured to maintain historical data in the current files. This would greatly simplify performing many types of before and after studies.

Separate or split alignments currently have to be treated as a single divided alignment. Similarly, the existing system cannot adequately handle ramps. With a little thought and effort, the software could be revised to handle those situations.

A number of other things could be done to improve HIS. Certain analysis procedures need further refinement, maintenance data could be added, and certain software modules (primarily the older ones) could be made more efficient and less dependent upon such uniquely Montana characteristics as 56 counties and 126 cities.

CHAPTER 6

AVAILABILITY OF SOFTWARE AND ADDITIONAL DOCUMENTATION

HIS is in the public domain and hence both the software and more detailed documentation are available upon request to the Chief, Planning and Research Bureau, Montana Department of Highways, Helena, Montana 59601. An appropriate charge might be made by the Department of Highways to recover their direct costs in fulfilling a request.

Software

HIS is a complex set of software comprising some 70,000 PL/I and basic assembly language source statements. It will only run on an IBM 360/370 computer and only under the OS operating system. Due to the interrelations of both the software and the data files, it is virtually impossible to isolate one particular subsystem or one particular program and attempt to implement it by itself.

Some of the software, particularly the older software, is very closely tied to such things as given card formats, given data element codes, 56 counties, 126 cities, all urban areas self-contained within a single county, no cities "embedded" within other cities, etc. Although software modifications were nearing completion, the Utah Department of Highways has abandoned a brief effort to implement HIS in their state. They were attempting to make the minimal possible software changes and to basically adopt Montana card formats and data element codes.

The Minnesota Department of Highways has decided to adopt a significantly modified version of HIS designed for their data and for their analysis requirements. To aid them in this work, they recently signed a long term contract with Montana State University. The University will be assisting them with system conception and will perform the vast majority of the software modifications.

Additional Documentation

Including this volume, Release 4.0 of HIS is documented in a total of eight volumes, two of which are so lengthy that they have been divided into several parts. Even excluding the program listings, these volumes make a very impressive stack. The specific volume titles and a brief description of their individual contents can be found in the FOREWORD of each volume (including this volume).